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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Protecting military convoys from sniper fire is a priority. A fielded green laser was evaluated for its capacity to interfere with the ability of a shooter to hit targets, both while on and after termination. We tested each subject???s ability to locate, identify, and hit a target using rifle-like armaments, during trials with or without laser exposure. Impairment was defined as fewer target hits during laser trials, compared to no-laser trials. Eight subjects each shot during 56 trials. On laser-exposure trials, Target 1 was presented concurrently with the laser, and Target 2 was presented immediately after removal of both Target 1 and the laser. Target 1 accuracy was significantly lower on laser trials (one-third as many hits) than on no-laser trials. Accuracy at Target 2 immediately following laser exposure did not differ from non-exposure trials. On non-exposure trials, no accuracies differed. Targeting impairment was not related to targeting skill of the shooter. Under dark shooting conditions at stationary, unpredictable, brief-exposure targets, an eye-safe green laser exposure impaired targeting success only while the laser shone on the shooter???s eyes, without residual effect. Lasers caused more performance interference here than in other reports. Interference mechanisms and situational contributors to effectiveness are suggested.

15. SUBJECT TERMS
laser, shooting accuracy, impairment, human behavior, suppression

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The Armament Research Development & Engineering Center

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Targeting Success is Disrupted by a Green Laser: Static, Unpredictable Targets Under Low Light

Target Behavioral Response Laboratory

Kenneth Short, Ph.D.; John Riedener, MSSE

The Problem

- Protecting military convoys from sniper fire is a priority.
- Soldiers would like to use non-injurious lasers in civilian settings to impair potential shooters to keep convoys safe.

Specific Objectives

- Determine effectiveness of a green laser under eye-safe conditions against the ability of a shooter to hit a target.
- Test laser effectiveness during laser exposure and immediately after laser exposure.

General Method

- Test human volunteers shooting under low lighting at briefly-available targets
- Compare shooting accuracy on laser-exposure trials with that on non-laser trials.

Target & Laser Arrangement

Shooter's Bench

Figure 1: *Target assembly, showing High target on left column and Low target on right column for illustrative purposes. During experiment trials, only one target would be visible at a time. The circular opening in the backdrop, partially visible between the target columns, allowed presentation of the laser to the subject's face, proximal to the target locations.*

Figure 2: *The shooter's bench with the paintball marker tethered to the rifle barrel rest. The opaque screen is raised in this view.*

Figure 3: *Target "hit" (left), and a "miss" (right) that was barely outside the "hit" criterion.*

Accuracy: Hits & Misses

Green Laser Interference Source

Figure 4: *The B.E. Meyers GBD-III-C green laser was tripod-mounted and placed behind a computer-controlled shutter to allow precise control over presentation. The laser was placed outdoors and shone through a bay door into the indoor targeting area, to accommodate the required 65-m laser exposure distance.*

Experimental Design & Procedures

- 8 healthy subjects with good eyesight participated
- Subjects were trained to criterion on shooting task
- Experiment consisted of 56 trials consisting of two targeting opportunities each, for 112 total targeting opportunities.
  - Subjects were presented with a pseudo-random presentation of target positions
  - Seven out of each of the 14 Target 1 presentations in each target position coincided with laser exposure for the full 1.4-sec target presentation duration.
    - 28 of the 56 trials began with laser exposure during Target 1 presentation
    - Laser exposures were fully balanced across target locations.
  - For each laser trial, a subject was exposed to the laser for the duration that the first target appeared.
  - When the first target was concealed, the laser was terminated simultaneously and immediately the second target appeared.
- Between trials, subjects were given a one-minute pause to prevent any cumulative laser exposure effects.

Shooting While Laser Is On Eyes:

Question: Does the laser interfere with hitting the target while it is on the eyes?

Findings

- Hit percentages were significantly lower for Target 1 when the laser was on than when off.
- 3 of 8 subjects did not shoot target at all – they reported they could not see it

Shooting After Laser Is Turned Off:

Question: Does the laser cause residual interference with targeting after it ends?

Findings

- Hit percentages did not differ from no-laser trials. There is no residual effect.

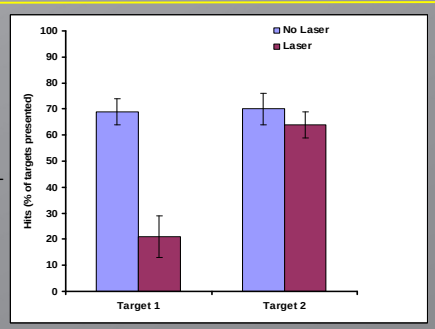

Figure 5: *Means and standard errors for hit rates on laser-exposure and non-exposure trials for the first and second targets in each trial.*

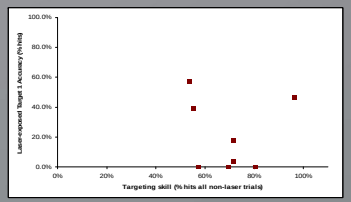

Figure 6: *Performance on non-laser trials, compared to impaired performance during laser exposure on Target 1 shots. Skill was not related to laser-induced impairment, predicting less than 1% of variance (R^2=.005).*

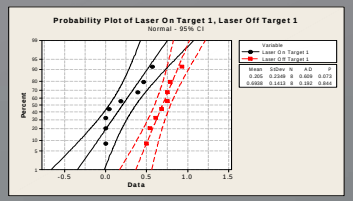

Figure 7: *Target 1 Hit percentages were normally-distributed whether the laser was on or off during targeting trials. Therefore ANOVA statistics were appropriate for assessing reliability of the impairment.*

Results Summary & Conclusions

- Targeting ability for Target 1 was seriously degraded by concurrent laser exposure.
  - Fewer than a third as many hits were scored on laser exposure trials than on non-exposure trials.
  - Subjects hit the first target on average 69% of the time (± 5% SEM) when no laser interference was present, but only 21% of the time (± 8% SEM) when the laser was present.
  - The difference in Target 1 hits was reliable according to Analysis of Variance (ANOVA) [$F_{1,15}$= 25.42, p<.001]
- There were no differences in targeting success for Target 2 between the laser-exposure trials and the non-exposure trials.
  - Any decrement in targeting accuracy on these trials would be expected to result from lingering effects of the laser, such as afterimages due to photo-pigment depletion or photoreceptor or other retinal cell fatigue, confusion, or undefined residual incapacitation.
  - On non-laser trials, subjects hit the second target 70% of the time (± 6% SEM), while on laser-exposure trials they hit 64% of the time (± 5% SEM) [Figure 5].
  - The small nominal difference is not reliable, according to a one-way ANOVA ($F_{1,15}$= 0.55, p=.471).
- On the non-exposure trials, targeting success for the first target (69.2% hits) and the second target (69.6% hits) of each trial did not differ (Figure 5).
  - Suggests that the difficulty of the two targeting tasks was similar.
    - Any difference in targeting accuracy between the two targets on the laser-exposure trials cannot be attributed to differential difficulty.

Discussion

- Unpredictability of the target location may have been essential for the laser to be able to interfere with targeting.
  - In another experiment (Short et al., 2007), truck-mounted targets were presented for a similar duration but in a *predictable* manner, and the same green laser was *not* effective.
- Alternatively, relevant feature may be sudden increase in light on subjects (temporal contrast).
  - Dark-acclimated (7 lux) subjects would have high sensitivity
  - Same laser was ineffective in daylight, more operational targeting test (Short et al., 2007).

Gather empirical data on real human behavior in response to non-lethal weapons and systems using real people in tactically relevant situations

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